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CERTIFICATION UNDER 37 CFR 1.10

I hereby certify that this Transmittal Letter and the papers indicated as being transmitted therewith are being deposited with the United States Postal Service on this date shown below in an envelope as "Express Mail Post Office to Addressee" under the below indicated Mailing Label Number, addressed to: Box PCT, Assistant Commissioner for Patents, Washington, D.C. 20231.

Mailing Label No.: EF297167718US

Deposit Date: March 20, 2001

Janet Farr

Name: Janet Farr

ATTORNEY'S DOCKET NO. YAMAP0757US

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
(DO/EO/US)

In re national phase of:

Applicant(s):	Henning Molsen
International Application No.:	PCT/JP99/05210
International Filing Date:	22 September 1999
Priority Date Claimed:	22 September 1998
Title of Invention:	TRANSFLECTIVE LIQUID CRYSTAL DISPLAYS

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING ENTRY INTO U.S. NATIONAL PHASE UNDER 35 U.S.C. 371

Box PCT
Assistant Commissioner for Patents
Washington D.C. 20231

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information under 35 U.S.C. 371:

1. This express request to immediately begin national examination procedures (35 U.S.C. 371(f)).

2. The U.S. National Fee (35 U.S.C. 371(c)(1)) and other fees (37 CFR 1.492) as indicated below.

3. A copy of the International application (35 U.S.C. 371(c)(2)):

   a. [x] is transmitted herewith (International Publication No. WO 00/17707).

   b. [ ] is not required, as the application was filed with the United States Receiving Office.

   c. [ ] has been transmitted by the International Bureau. A copy of Form PCT/IB/308 is enclosed.

4. [ ] A translation of the International application into the English language (35 U.S.C. 371(c)(2)) is transmitted herewith.

5. Amendments to the claims of the International application under PCT Article 19 (35 U.S.C. 371(c)(3)):

   a. [ ] are transmitted herewith.

   b. [ ] have been transmitted by the International Bureau.

6. [ ] A translation of the amendments to the claims under PCT Article 19 (38 U.S.C. 371(c)(3)) is transmitted herewith.

7. A copy of the international examination report (PCT/IPEA/409)

   a. [ ] is transmitted herewith.

   b. [ ] is not required as the United States Patent and Trademark Office was the IPEA.

8. Annex(es) to the international preliminary examination report

   a. [ ] is/are transmitted herewith.

   b. [ ] is not required as the United States Patent and Trademark Office was the IPEA.

9. [ ] A translation of the annexes to the international preliminary examination report is transmitted herewith.

10. [ ] An oath or declaration of the inventor (35 U.S.C. 371(c)(4)) complying with 35 U.S.C. 115 is submitted herewith.

11. An International Search Report (PCT/ISA/210)

    a. [x] is transmitted herewith.

    b. [ ] has been transmitted by the International Bureau.

    c. [ ] is not required, as the application was searched by the United States International Searching Authority.

12. [ ] An Information Disclosure Statement under 37 CFR 1.97 and 1.98 is transmitted herewith, along with Form PTO-1449 and copies of citations listed.

13. [ ] An assignment document is transmitted herewith for recording, along with a separate cover sheet.

14. [x] A preliminary amendment is enclosed.

15. [ ] A verified statement claiming small entity status is enclosed.

16. [ ] Other:

Basic National Fee					Fee
IPEA - US				$690.00	
ISA - US				$710.00	
PTO not ISA or IPEA				$1,000.00	
Claims meet PCT Art. 33(1)-(4) - IPEA - US				$100.00	
Filing with EPO or JPO search report				$860.00	
Enter appropriate basic fee ➜					$860.00
Claims*	Number filed		Number extra	Rate	
Total claims	45	-20	25	$18.00	$450.00
Independent claims	2	-3	0	$80.00	$0.00
Multiple dependent claims (if applicable)				$270.00	
Total of above					$1,310.00
Small entity statement enclosed, 1 if Yes, 0 if No ➜				0	$0.00
Total national fee					$1,310.00
Fee for recording enclosed assignment				$40.00	
Total fees enclosed					$1,310.00

*After any attached preliminary amendment reducing the number of claims and/or deleting multiple dependencies.

[X] A check in the amount of $ 1,310.00 to cover the above fees is enclosed.

[ ] Please charge our Deposit Account No. 18-0988 in the amount of $________. A duplicate copy of this sheet is enclosed.

WARNING: TO AVOID ABANDONMENT OF THE APPLICATION THE BASIC NATIONAL FEE MUST BE PAID WITHIN THE 20/30 MONTH TIME LIMIT.

16. The Commissioner is hereby authorized to charge the following additional fees that may be required by this paper and during the entire pendency of this application to our Deposit Account No. 18-0988:

a. [X] 37 CFR 1.492(a)(1), (2), (3), (4) and (5) (filing fees)

WARNING: BECAUSE FAILURE TO PAY THE NATIONAL FEE WITHIN 30 MONTHS WITHOUT EXTENSION (37 CFR S 1.495(B)(2)) RESULTS IN ABANDONMENT OF THE APPLICATION, IT WOULD BE BEST TO ALWAYS CHECK THE ABOVE BOX.

b. [ ] 37 CFR 1.492(b), (c) and (d) (presentation of extra claims)

NOTE: Because additional fees for excess or multiple dependent claims not paid on filing or on later presentation must only be paid or these claims cancelled by amendment prior to the expiration of the time period set for response by the PTO in any notice of fee deficiency (37 CFR 1.492(d)), it might be best not to authorize the PTO to charge additional claim fees, except possibly when dealing with amendments after final action.

Respectfully submitted,

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YAMAP0757US

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of	:	
Molsen et al.	:	Art Unit:
Express Mail: EF297167718US	:	Examiner:
Filed: March 20, 2001	:	

For: TRANSFLECTIVE CRYSTAL DISPLAYS

PRELIMINARY AMENDMENT

Box PCT
Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to commencing examination of the above-identified application, entry of the following amendment is respectfully requested.

In the Claims:

Kindly cancel claims 1-24, without prejudice.

Kindly add claims 25-69, as follows:

25. A transflective liquid crystal display comprising:

a liquid crystal disposed between a front substrate and a rear substrate,

a front polariser located in front of the front substrate and rear polariser located behind the rear substrate,

a front retarder located between the front substrate and the front polariser, and

a rear retarder located between the rear substrate and the rear polariser, and addressing means for addressing each pixel and switching each pixel between different states resulting in different levels of transmission of light through the display, characterised in that,

a light source is located behind the rear polariser, and

the liquid crystal display is provided with a rear electrode which is partially reflective and partially transmissive and the liquid crystal is divided into a plurality of pixels.

26. A transflective display as claimed in claim25, wherein

the front retarder is an achromatic combination retarder.

27. A transflective display as claimed in claim 25,wherein the front retarder comprises a front halfwave plate and a ftont quarterwave plate.

28. A transflective display as claimed in claim 27,wherein the front quarterwave plate has a slow axis substantially parallel or normal to a bisetrix of surface alignment directions of the liquid crystal, such that a retardation of the front quarterwave plate, in conjunction with the retardation of the liquid crystal, produces in one state circular polarised light after a single pass.

29. A transflective display as claimed in claim 27,wherein the front quarterwave plate has a slow axis substantially parallel or normal to a bisetrix of surface alignment directions of the liquid crystal, such that a retardation of the front quarterwave plate, in conjunction with the retardation of the liquid crystal, produces in a second state linear polarised light after a single pass.

30. A transflective display as claimed in claim 27,wherein

the front quarterwave plate has a retardation of between 50nm and 250 nm.

31. A transflective display as claimed in claim 25, wherein the rear retarder comprises a rear quarterwave plate.

32. A transflective display as claimed in claim 31, wherein the rear quarterwave plate has a slow axis substantially parallel or normal to a bisetrix of surface alignment directions of the liquid crystal, such that a retardation of the rear quarterwave plate, in conjunction with the retardation of the liquid crystal and the front quarterwave plate, produces in one state circular polarised light after a single pass.

33. A transflective display as claimed in claim 27, wherein the rear retarder comprises a rear quarterwave plate, and the rear quarterwave plate has a slow axis substantially parallel or normal to a bisetrix of surface alignment directions of the liquid crystal, such that a retardation of the rear quarterwave plate, in conjunction with the retardation of the liquid crystal and the front quarterwave plate, produces in a second state linear polarised light

after a single pass.

34. A transflective display as claimed in claim 31, wherein the rear quarterwave plate has a retardation of between 100nm and 180nm.

35. A transflective display as claimed in claim 25 wherein the rear substrate is provided with a partially reflective and partially transmissive mirror.

36. A transflective display as claimed in claim 25 wherein the rear retarder further comprises a rear halfwave plate.

37. A transflective display as claimed in claim 30, wherein the rear retarder further comprises a rear halfwave plate and the rear halfwave plate is located between the rear quarterwave plate and the rear polariser.

38. A transflective display comprising a liquid crystal divided into a plurality of pixels, addressing means for addressing each pixel and swithing each pixel between different states resulting in different levels of transmission of light through the display, a flashing

backlight located behind the liquid crystal, and a partially reflective mirror located between the liquid crystal and the backlight for both reflecting ambient light back through the liquid crystal and allowing transmission of light from the backlight through the liquid erystal, characterised in that each pixel is provided with a light filter, and the backlight comprises a plurality of sequentially flashing light sources.

39. A transflective display as claimed in claim 38, wherein each light filter is a colour light filter, and wherein said sequentially flashing light sources are of different colours.

40. A transflective display as claimed in claim 39, wherein said liquid crystal is part of an active matrix display.

41. A transflective display as claimed in claim 38, wherein the liquid crystal forms a Pi or OCB cell.

42. A transflective display as claimed in claim 38, wherein each said sequentially flashing light source is

a light emitting diode (LED).

43. A transflective display as claimed in claim 39, wherein each colour filter provides a varying level of absorption across its area.

44. A transflective display as claimed in claim 43, wherein each colour filter has a transparent region.

45. A transflective display as claimed in claim 44, wherein said liquid crystal is provided with a plurality of partially reflective electrodes each having a light transmissive area, and wherein each said transmissive area is optically aligned with a transparent region of one of said colour filters.

56. A transflective display as claimed in claim 38, wherein the transflective liquid crystal display comprises

a liquid crystal disposed between a front substrate and a rear substrate,

a front polariser located in front of the front substrate and rear polariser located behind the rear substrate,

a front retarder located between the front substrate and the front polariser, and

a rear retarder located between the rear substrate and the rear polariser, and addressing means for addressing each pixel and switching each pixel between different states resulting in different levels of transmission of light through the display, characterised in that,

a light source is located behind the rear polariser, and

the liquid crystal display is provided with a rear electrode which is partially reflective and partially transmissive and the liquid crystal is divided into a plurality of pixels.

47. A transflective display as claimed in claim 35, wherein said partially reflective and partially transmissive mirror comprises a plurality of gaps or holes.

48. A transflective display as claimed in claim 38, wherein said partially reflective and partially transmissive mirror comprises a plurality of gaps or holes.

49. A transflective display as claimed in claim 35,

wherein said partially reflective and partially transmissive mirror is a mirror transparent to a predetermined value between 10 and 90%.

50. A transflective display as claimed in claim 38, wherein said partially reflective and partially transmissive mirror is a mirror transparent to a predetermined value between 10 and 90%.

51. A transflective display as claimed in claim 39, wherein for transmission, transflective and reflection modes of the transflective display a voltage level for each said different colour is individually adjusted.

52. A transflective display as claimed in claim 25, wherein said front and rear polarisers are parallel polarisers.

53. A transflective display as claimed in claim 38, wherein said front and rear polarisers are parallel polarisers.

54. A transflective display as claimed in claim 25, wherein said front and rear polarisers are crossed polarisers.

55. A transflective display as claimed in claim 38, wherein said front and rear polarisers are crossed polarisers.

56. A transflective display as claimed in claim 25, in which the effective retardation of the nematic LC is continuously switchable, and, the two front retarders function together as an achromatic combination retarder.

57. A transflective display as claimed in claim 38, in which the effective retardation of the nematic LC is continuously switchable, and, the two front retarders function together as an achromatic combination retarder.

58. A transflective display as claimed in claim 25, in which the effective retardation of the nematic LC is continuously switchable, and, the two rear retarders function together as an achromatic combination retarder.

59. A transflective display as claimed in claim 38, in which the effective retardation of the nematic LC is continuously switchable, and, the two rear retarders function together as an achromatic combination retarder.

60. A transflective display as claimed in claim 25, in which the front quarter wave plate has its slow axis substantially normal or parallel to the bisectrix of the surface director orientations of the nematic LC, and the two front retarders form an achromatic combination retarder, and the combination retarder is modified to compensate for the residual retardation of the LC at finite voltages.

61. A transflective display as claimed in claim 38, in which the front quarter wave plate has its slow axis substantially normal or parallel to the bisectrix of the surface director orientations of the nematic LC, and the two front retarders form an achromatic combination retarder, and the combination retarder is modified to compensate for the residual retardation of the LC at finite voltages.

62. A transflective display as claimed in claim 25 in which the rear quarter wave plate has its slow axis substantially normal or parallel to the bisectrix of the surface director orientations of the nematic LC, and the two rear retarders form an achromatic combination retarder, and the combination retarder is modified to compensate for the

residual retardation of the LC at finite voltages.

63. A transflective display as claimed in claim 38, in which the rear quarter wave plate has its slow axis substantially normal or parallel to the bisectrix of the surface director orientations of the nematic LC, and the two rear retarders form an achromatic combination retarder, and the combination retarder is modified to compensate for the residual retardation of the LC at finite voltages.

64. A transflective display as claimed in claim 25, which the nematic LC has antiparallel surface director orientation with surface pretilt, and the front substrate functions as a colour filter plate.

65. A transflective display as claimed in claim 38, which the nematic LC has antiparallel surface director orientation with surface pretilt, and the front substrate functions as a colour filter plate.

66. A transflective display as claimed in claim 25, which the red, green and blue voltage levels are individually adjusted for transmission, transflective or reflection

REMARKS

Claims 1-24 have been canceled, without prejudice. Claims 25-69 have been added. Claims 25-69 are in the application upon entry of this amendment. Entry of this amendment is respectfully requested.

New claims 25-69 have been submitted to replace original claims 1-24 in order to present a set of claims consistent with U.S. Patent Office formality requirements.

Respectfully submitted,

RENNER, OTTO, BOISSELLE & SKLAR, P.L.L.

By______________________________
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09/787594

DESCRIPTION

Transflective Liquid Crystal Displays

TECHNICAL FIELD

The invention relates to transflective liquid crystal displays, which rely for their operation on reflection of ambient light, and transmission of light from a backlight in the case of a low ambient light level to achieve excellent readability in all lighting conditions.

BACKGROUND ART

European Patent Publication No. 0,840,160 A2 describes a Pancharatnam-type achromatic (ie, independent of frequency/colour) reflective liquid crystal display (LCD) using a twisted nematic liquid crystal (LC) layer as part of a switchable achromatic retarder.

British Patent Application No. 9806566.7 describes an improved retarder combination for an achromatic fixed retarder and twisted nematic (TN) LC used in high resolution thin film transistor (HR-TFT) displays, which reduces threshold voltage and chromaticity and improves contrast.

S. Fujiwara et al. "Proceedings of the Fourth International Display Workshops", Nagoya 1997, (IDW'97), p.879 describes a reflective LCD using an achromatic fixed retarder between a linear polariser and a twisted nematic LC. This is used in the HR-TFT LCD product produced by Sharp.

Solutions for converting linear polarised light to circular polarised light by a twisted nematic layer with respect to the LC parameters retardation, twist and alignment orientation can be found in Beynon et al., Proceedings of the International Display research Conference, 1997 L34.

US Patent No. 5,361,151 (Sonehara) describes a transflective LCD comprising a TN-LC layer, an internal or external semi-reflector, and chromatic retardation plates between the LC and the front and rear linear polariser.

US Patent No. 4,093,356 (J. E. Bigelow) describes a transflective liquid crystal display capable of presenting viewable indicia to an observer positioned at the front thereof,

which is responsive to either reflection of incident ambient light entering into the display from the front thereof, or transmission of light from a source behind the display, and which utilises a reflective display of the type having a nematic liquid crystal host-guest dichroic dye cell backed by a quarterwave plate and partially reflective, partially transmissive transflector member, in conjunction with a linear polariser and a second quarterwave plate arranged between the backlighting source and the partially transmissive member.

In such a guest-host cell, the dichroic dye is regarded as a guest in the liquid crystal, because the orientation of the dichroic dye molecules simply follows that of the LC molecules. The dye molecules are generally transparent when viewed along their long axes, and opaque (ie. they absorb visible light) when viewed perpendicular to their long axes, and are hence referred to as dichroic. Consequently, by applying a voltage to the LC cell, the degree of absorption in the cell can be controlled, and the cell is therefore sometimes referred to as operating in an absorption mode.

The rear quarterwave plate is used to compensate for the front quarterwave plate so that linear polarised light impinges on the guest-host liquid crystal (GH-LC).

US Patent No. 4,315,258 (McKnight et al.) describes a visual display which has an increased readout capability due to its operation in a transflective mode. A source of ambient light and light for radiation through the display from the back together assure the increased readout capability. Previously, ambient light would degrade or wash-out the display making it nearly impossible for monitoring personnel to decipher alphanumeric or pictoral displays due to the decreased contrast. A pair of linear polarizers sandwich a twisted nematic liquid crystal and have their polarisation axes either parallel or mutually orthogonally disposed so that the crystal presents bright or dark areas in response to applied potentials. Because a partially transmitting mirror is interposed between the sandwiched liquid crystal and the radiating light source, the ambient light augments the radiated light to enhance the visual display.

It should be understood that, throughout this specification, references to retardation values should be understood as effective retardation values, taking into account the twist angle of the retarder. A twisted birefringent structure (such as a TNLC) has a retardation of thickness x birefringence for a particular wavelength. However, it effects a retardation which is lower or higher depending on the twist angle.

DISCLOSURE OF INVENTION

According to a first aspect of the invention there is provided a transflective liquid crystal display comprising a liquid crystal cell disposed between a front substrate and a rear substrate, a front achromatic retarder located in front of the front substrate and a rear polariser located behind the rear substrate, a front retarder located between the front substrate and the front polariser, a rear retarder located between the rear substrate and the rear polariser, a light source located behind the rear polariser, and a partially transparent/partially reflective layer (for example a semi-transparent mirror, transflector) between the liquid crystal layer and said light source.

This allows the display to benefit from backlighting in low ambient light conditions and high contrast while still providing the benefits of an achromatic reflective display.

The front retarder may comprise a front halfwave plate and a front quarterwave plate.

The front quarterwave plate may have a retardation of between 0nm and 250nm.

The front halfwave plate may have a retardation of between 200nm and 360nm.

The rear retarder may comprise a rear quarterwave plate.

The rear quarterwave plate may have a retardation of between 100nm and 180nm, and preferably of substantially 135 nm.

The rear substrate may be provided with a partially reflective and partially transmissive mirror.

The liquid crystal cell may be provided with a rear electrode, which is partially reflective and partially transmissive.

The rear retarder may further comprise a rear halfwave plate.

The rear halfwave plate may have a retardation of between 200nm and 360nm.

The rear halfwave plate may be located between the rear quarterwave plate and the rear polariser.

In order to use the same LC profile and thickness and the same operating mode (normally white) for reflective and transmissive modes of operation, the backlight can be manipulated first by a linear polariser followed by a quarter wave plate at 45° to the polarisation or absorption direction.

The invention broadens the usability of reflective LCDs by incorporating a backlight. This is achieved without major alteration to the existing HR-TFT fabrication process. As compared with front lighting systems the contrast ratio of the LCD using a backlight is not reduced. Although the transmission may be only 50% of the ideal value this is not critical to the readability of the LCD as the backlight will only be operated at low ambient light levels. The invention can also operate in normally black mode either in both transmission and reflection or transmission by changing the azimuth angle of both polarisers by 45° in the same direction.

The process flow to manufacture the internal reflector in the HR-TFT requires only one additional step. To secure uniform electric fields the etched window in the aluminium can be sputter-coated with indium tin oxide (ITO) in a self-aligning process. Surplus ITO on the photoresist used to pattern the aluminium mirror can be removed during the photoresist development or removal/strip. Multiple windows can be randomly distributed over the pixel to avoid diffraction.

Alternatively, the reflective layers can be thinned to an extent that it becomes partially transmissive to a predetermined value over the whole or part of the pixel electrode.

According to a second aspect of the invention, there is provided a transflective display comprising a liquid crystal divided into a plurality of pixels, addressing means for addressing each pixel and switching each pixel between different states resulting in different levels of transmission of light through the display, a flashing backlight located behind the liquid crystal, and a partially transparent/partially reflective layer (for example a semi-transparent mirror, transflector) between the liquid crystal layer and said flashing backlight for both reflecting ambient light back through the liquid crystal and allowing transmission of light from the backlight through the liquid crystal, wherein each pixel is provided with a light filter, and wherein the backlight comprises a plurality of sequentially flashing light sources.

In one embodiment, of the invention, each light filter is a colour light filter, and said sequentially flashing light sources are of different colours.

Said liquid crystal may be part of an active matrix display.

In one embodiment, the liquid crystal forms a Pi or optically compensated birefringent (OCB) cell.

In a further embodiment, each light source is a light emitting diode (LED).

Each colour filter may provide a varying level of absorption across its area.

Each colour filter may have a transparent region.

This provides the advantage of ensuring that a greater amount of light from each light source can pass through every colour filter.

In this case, said liquid crystal may be provided with a plurality of partially

reflective electrodes each having a light transmissive area, and each transmissive area may be optically aligned with a transparent region of one of said colour filters.

The transflective display of the second aspect of the invention may also have any or all of the features of the transflective display of the first aspect of the invention.

BRIEF DESCRIPTION OF DRAWINGS

The invention will now be more particularly described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows the arrangement described in US Patent No. 4,093,356 (mentioned above), which uses a quarterwave plate between a rear polariser and a reflector in a transflective GH LCD;

Figure 2 is a schematic view of a transflective LCD according to a first embodiment of the invention;

Figure 3 shows the results of modelling the LC electrooptic response of the embodiment of Figure 2;

Figure 3a shows the results of modelling the LC electrooptic response of the embodiment of Figure 2, but using crossed polarisers.

Figure 4 is a schematic view of a transflective LCD according to a second embodiment of this invention;

Figure 5 shows the results of modelling the LC electrooptic response of the embodiment of Figure 4;

Figure 6 is a schematic view of a transflective LCD according to a third embodiment of this invention.

Figure 7 shows the results of modelling the LC electrooptic response of the embodiment of Figure 6;

Figure 7a shows the results of modelling the LC electrooptic response of the embodiment of Figure 6, but using crossed polarisers;

Figure 8 is a schematic view of a transflective LCD according to a fourth embodiment of this invention.

Figure 9 shows the results of modelling the LC electrooptic response of the embodiment of Figure 8;

Figure 10 is a schematic diagram of the prior art pixellated reflective LCD with internal reflectors described in the Fujiwara reference mentioned above;

Figure 11 is a schematic diagram of a pixellated transflective LCD with internal reflectors and a transmission window in accordance with the invention.

Figure 12 shows a transflective LCD using a Pi or OCB cell, which is an embodiment of a second aspect of the invention;

Figure 13 shows the results of modelling the LC electrooptic response of the embodiment of Figure 12; and

Figure 14 shows the results of modelling of the LC electrooptic response of the embodiment of Figure 12, and shows the wavelength dependence of the electrooptic response for transmission and reflection in both the switched and unswitched states.

BEST MODE FOR CARRYING OUT THE INVENTION

The prior art transflective guest-host (GH) LCD 2 shown in Figure 1 comprises a light source 4, linear polariser 6, first quarterwave plate 8, partially transmissive mirror 10, second quarterwave plate 12, rear substrate 14, guest-host liquid crystal (GH-LC) cell 16, and front substrate 18.

The quarterwave plates (or retarders) 8 and 12 and the linear polariser 6 are formed from stretched polymer films. The GH-LC cell 16 contains a dichroic dye, the

molecules of which are oriented by the LC molecules in order to control the degree of absorption of the cell. The cell thus operates in an absorption mode. The GH-LC cell 16 is pixellated, with each pixel being controlled by a pair of electrodes (not shown) in known manner.

The display 2 is viewed from the position of the viewer 20. The light reaching the viewer 20 from the display is a combination of light from the light source 4 and (usually white) ambient light reflected by the partially reflective mirror 10. It is for this reason that the display is referred to as transflective, because it operates on the basis of both transmission and reflection.

The first embodiment of the invention, shown in Figure 2, is a transflective liquid crystal display 28 comprising a light source 30, a rear polariser 32, rear quarterwave plate 34, rear substrate 36, liquid crystal cell 38, front substrate 40, front quarterwave plate 42, front halfwave plate 44, and front polariser 46. The location of the viewer 20 is also indicated in Figure 2.

The arrangement of components of the display 28 from the front polariser 46 to the rear substrate 36 (inclusive) is known from the Fujiwara reference mentioned above, except that the rear substrate 36 of the display 28 is provided with a partially reflecting (and partially transmitting) mirror (not shown separately) instead of a fully reflecting mirror.

Figure 2 also indicates for each of the retarders 34, 42 and 44, the angle that the slow axis of the retarder makes with respect to the angle of the absorption axes of the two polarisers 32 and 46 (which are parallel, and defined as 0 degrees). These angles are -45°, -75° and -15° respectively. In addition, the angles at which the LC molecules are aligned by alignment layers (not shown) at the surfaces 48 and 50 of the LC cell 38 are also indicated in Figure 2. The surface director orientations (SDOs) are -20° and +50°, respectively. The term "surface director orientation" as used herein is defined as the orientation of the LC director at an alignment surface projected onto the plane of the alignment surface of the LC layer, so that the SDO is the orientation which the LC

director would have in the absence of any surface pretilt. Also, the SDO is equivalent to ($SDO \pm \pi$). The twist of the LC layer may be between 30° and 100°, preferably between 60° and 80°.

The two transparent parallel substrates 36 and 40 are each coated on the inside surfaces 52 and 54 with a patterned conductor/electrode (not shown) for addressing the LC cell 38, with the rear electrode being patterned and partially transparent and partially reflecting. The ratio of transmission to reflection of the rear conductor/electrode may be 1:1 or any other pre-determined value according to the designated purpose of the transflective display 28. The electrodes are coated with alignment means and hold the nematic LC cell 38 continuously switchable between an effective retardation in the reflecting bright state of 80nm to 200nm, and preferably 135nm, and in the dark state of 50nm to 0nm, and preferably close to 0nm. The nematic LC may be twisted by surface alignment and/or chiral doping.

The outer sides of the substrates 36 and 40 are clad by the transparent retardation films 34, 42 and 44. The front halfwave retarder 44 has a retardation $d\Delta n$ of substantially 270nm and the front quarterwave retarder 42 has a retardation $d\Delta n$ of substantially 133nm, where d represents the thickness of the retarder film, and Δn represents the difference between the two refractive indices of the retarder film. The front quarterwave retarder 42 has its slow axis substantially parallel or normal to the bisetrix (ie. half the angle) of the (twist or) surface alignment directions of the nematic LC cell 38. (The angle -75° for the quarterwave retarder shown in Figure 2 is normal to the bisetrix of the SDOs of -20° and +50° of the twisted nematic LC cell 38.). The two front retarders 42 aud 44 form an achromatic combination retarder. The rear retarder 34 has a retardation $d\Delta n$ of substantially 133nm. The absorption or polarisation axis of the rear polariser 32 is at 45 degrees to the slow axis of the rear retardation film 34. The LC cell 38 may be MJ 96539 (Merck Japan), the retardation films 34, 42 and 44 of Nitto's NRZ range, and the polarisers 32 and 46 of Nitto's NPF range.

The bisetrix, or bisector, as used herein is the direction which bisects the smaller included angle between two directions. The bisetrix is also perpendicular to the

optical axis of the device.

Figure 3 shows the results of computer modelling of the electrooptic response of the embodiment of Figure 2. The modelling was carried out assuming a standardised D65 light source for reflected and transmitted light in the wavelength range of 380 to 780 nm. The design wavelength for-optimum performance is 550 nm and matched to the eye's maximum sensitivity. The liquid crystal is MJ96539 with $\Delta n=0.068539$ at 550 nm, the LC layer thickness is set to 3.121 μm. The dispersion of the LC is taken into account, any dispersion in the retarders is neglected. The graph of Figure 3 shows voltage (applied to a pixel of the LC cell 38) against transmission and reflection in arbitrary units. The transmission results are shown by curve 56, and the reflection results by curve 58. For the reflection results a 0.1 micron aluminium mirror is assumed, and for the transmission results the mirror was removed.

When no voltage is applied, both the transmission and reflection are high, and the display thus operates in a "normally white mode". The rear quarterwave plate 34 is necessary in order to ensure that the transmission curve 56 is the correct way around. Without the quarterwave plate 34 the transmission curve 56 would be low at zero volts and high at 5 volts. It will be seen from Figure 3 that even at 4 or 5 volts there is still some residual transmission and reflection, which prevents the pixel from becoming fully dark. The embodiments discussed below seek to provide an improved contrast between the light and dark states.

Figure 3a shows the results of modelling the LC electrooptic response of the embodiment of Figure 2, but using crossed polarisers instead of parallel polarisers. That is, to produce the results of Figure 3a, the last two components (ie, the quarterwave plate 34 and polariser 32) are rotated through 90° compared to the arrangement shown in Figure 2. This results in a better (ie, darker) dark state for the transmission curve 56. The reflection curve is again labelled 58.

Figure 4 shows a second embodiment of the invention, which is a transflective display 60 providing reduced residual transmission in the dark state. Components which are the same as those of the first embodiment of Figure 2 are given the same reference numerals. The display of Figure 4 differs from that of Figure 2 in that the rear quarterwave plate 34 is replaced by a rear halfwave plate 62 and a rear quarterwave

plate 64, which have slow axes at -15° and -75° respectively with respect to the absorption axes of the two polarisers 32 and 46. As shown by Figure 4, the components thus exhibit a degree of symmetry about the central LC cell 38. The combination of the

rear halfwave plate and rear quarterwave plate improves the achromaticity of the transmission mode.

The effective retardation of the nematic LC cell 38 is continuously switchable between about 135nm and 0nm in the same way as in the embodiment of Figure 2. The two front retarders 42 and 44 function together as an achromatic combination retarder, and the two rear retarders 62 and 64 also function together as an achromatic combination retarder. The retardation films can again be of Nitto's NRZ range.

Figure 5 shows the results of computer modelling of the electrooptic response of the embodiment of Figure 4. The transmission results are shown by curve 66, and the reflection results by curve 68. The assumptions mentioned above in relation to the graph of Figure 3 apply equally to the Figure 5. As shown by Figure 5, the embodiment of Figure 4 produces a slight reduction in the residual transmission (at around 4 to 5 volts) compared with the embodiment of Figure 2.

Figure 6 shows a third embodiment of the invention, which is a transflective display 70 providing both significantly reduced residual transmission and significantly reduced residual reflection. The components are essentially the same as those of the embodiment of Figure 4, and the same reference numerals are therefore used. However, the display 70 differs from that of Figure 4 in that the thickness of the front quarterwave plate (retarder) 42 is increased so that it has a retardation $d\Delta n$ of substantially 150 nm.

The front and rear quarterwave plates 42 and 64 have their slow axes substantially normal to the bisetrix of the surface director orientations of the nematic LC cell 38. The two front retarders 42 and 44, and the two rear retarders 62 and 64, each form an achromatic combination retarder. The front achromatic combination retarder is modified to compensate for the residual retardation of the LC cell at finite voltages. The retardation of quarterwave plate 42 is increased when the slow axis of each quarterwave plate is normal to the bisetrix of the SDOs of the nematic LC cell 38. Alternatively, if the slow axes of the quarterwave plates 42 and 64 are parallel to the bisetrix of the SDOs of the nematic LC cell 38, the retardation of

quarterwave plate 42 needs to be decreased. The retardation films can again be of Nitto's NRZ range.

Figure 7 shows the results of computer modelling of the electrooptic response of the embodiment of Figure 6. The transmission results are shown by curve 72, and the reflection results by curve 74. The assumptions mentioned above in relation to the graph of Figure 3 apply equally to the Figure 7. As shown by Figure 7, the embodiment of Figure 6 produces a significant reduction in both the residual transmission and the residual reflection in the dark state (at around 4 to 5 volts) compared with the previous embodiments.

This improvement comes about because the increased thickness of the quarterwave plate 42 compensates for the residual retardation caused by the fact that those liquid crystal molecules in the LC cell 38 which lie close to the alignment layers (not shown separately) remain "fixed" in position when the LC cell 38 is switched by application of an external voltage.

Figure 7a uses the same reference numbers as Figure 7, and shows an improved (ie. darker) dark state and increased bright state for the transmission curve 56, achieved by rotating the last three components (ie. 32, 62 and 64) of Figure 6 through 90°, so that the polarisers 32 and 46 are crossed.

Figure 8 shows a fourth embodiment of the invention. The components of the transflective display 100 are essentially the same as those of the embodiments of Figures 4 and 6, and the same reference numerals are therefore used for components which are the same. However, the nematic LC cell 38 of Figures 4 and 6 is replaced by a hybrid aligned nematic (HAN) LC cell 102. The cell 102 used is LC MJ96539 produced by Merck, Japan and has antiparallel surface director orientation with surface pretilt of 2° and 88°, respectively, and a retardation of substantially 137.5 nm. The orientations and retardations of the other components are given in Figure 8. The front substrate 40 also functions as a colour filter plate. The retardation of the front quarterwave plate 42 is 150 nm.

Figure 9 shows the results of computer modelling of the electrooptic response of the embodiment of Figure 8. The transmission results are shown by curve 104, and the reflection results by curve 106.

Figure 9a uses the same reference numbers as Figure 9, and shows an improved (ie. darker) dark state for the transmission curve 104, achieved by rotating the last three components (ie. 32, 62 and 64) of Figure 8 through 90°, so that the polarisers 32 and 46 are crossed.

In any of the embodiments of the invention the partially reflective (and partially transmissive) mirror (not shown separately) provided on the rear substrate 36 can be either a mirror containing a number of gaps or holes, or a continuous mirror which is transparent to a predetermined value of say between 10% and 90%.

Figure 10 shows the layout of the prior art reflective LCD 76 described in the paper by S. Fujiwara mentioned above. From top to bottom, the display 76 comprises a polariser 78, one or more retardation films 80, micro colour filters 82, a front substrate 84, a liquid crystal layer 86 (represented schematically by liquid crystal molecules 87, reflective electrodes 88 controlled by thin film transistor (TFT) elements 90, and a rear substrate 92. Three colour filters 82, representing red, blue and green, are shown in Figure 10, each covering two reflective electrodes 88. Each electrode 88 corresponds to a subpixel. Figure 10 thus shows two pixels, each comprising three subpixels having red, blue and green filters. The liquid crystal molecules 87 located under the green filter 82 are shown switched, whereas the other liquid crystal molecules 87 are shown unswitched.

Figure 11 shows the layout of a transflective LCD in accordance with the invention. Where components correspond to those in Figure 10 the same reference numerals are used. The arrangement of Figure 11 differs from that of Figure 10 by the addition of one or more retardation films 92, a rear polariser 94, and a backlight 96. In addition the reflecting electrodes 88 are made partially transmissive by providing the electrodes 88

with apertures 98. As an alternative, the electrodes 88 can be made of a continuous partially transmissive material.

In any embodiment the red, green and blue voltage levels can be individually adjusted for transmission, transflective or reflection modes. The transmission/reflection against voltage curve is wavelength dependent and can be different between the reflective and the transmissive mode. Hence data voltages must be adjusted according to the mode used.

Each micro colour filter 82 can have areas of different absorption to achieve the best colour balance/saturation for transmission and reflection modes.

The invention can use LC modes switching substantially in the plane of the LC cell, so-called in-plane switching modes, found for example in ferroelectric, antiferroelectric and some nematic LC modes. The invention can also use out-of-plane switching modes, and is not limited to twisted nematics. For example, surface switching LC modes can be used.

Retardation values, twist angles, and other orientation angles given for the embodiments described above are examples only.

Embodiments of a second aspect of the invention will now be described.

Figure 12 shows a transfective LCD 100 which is capable of time sequential colour illumination. Components which are the same as those in Figure 8 are given the same reference numerals. The transflective LCD 100 comprises: three flashing LEDs, which are red 102, green 104 and blue 106, a rear polariser 32, a rear halfwave plate 62, a rear quarterwave plate 108, a rear substrate 36 provided with a partially reflecting mirror, a Pi or OCB cell 110 formed from the LC material TL203 made by Merck, a front substrate 40 provided with colour filters, a front quarterwave plate 112, a front halfwave plate 44 and a front polariser 46. The front quarterwave plate 112 has a retardation of 214nm. The increased retardation of the front quarterwave plate 112 is required to

compensate for the larger residual retardation of the Pi cell at finite voltages compared to the HAN and TN cell.

The angles which the slow axes of the retarders 62, 108, 112 and 44 make with respect to the absorption axes of the two polarisers 32 and 46 (defined as 0 degrees) are indicated in Figure 12, together with the retardation values of the retarders. Figure 12 also shows that the Pi cell 110 has zero twist.

The embodiment of Figure 12 also makes use of micro colour filters 82, as shown in Figure 11. When the ambient light level is low, the transflective LCD 100 switches (either automatically or manually) to a time sequential transmission mode in which the red, green and blue LEDs 102, 104 and 106 flash in turn. The pixels of the Pi cell 110 are addressed for each flash. This is why it is desirable to use a Pi cell rather than a TN LC cell, because a Pi cell can be switched more quickly.

It is possible to address the pixels of the Pi cell 110 in different ways. In the simplest case, when the green LED 104 is flashed, only the pixels with green micro colour filters 82 are switched on, and the other pixels are switched off (ie. to a zero transmission state).

However, if the micro colour filters 82 are sufficiently wide band, then each colour filter 82 will let through some light of each other colour. For example, the green filters which let through some red and blue light. In this case, it is possible to make use of all of the pixels for all of the coloured LEDs, provided that the transmission characteristics of the micro colour filters 82 are taken into account when addressing the pixels. In this way it is possible to increase both the light throughput and the resolution of the display, because when the green LED 104 is flashed, for example, light can pass through pixels having micro colour filters 82 of any colour.

It is still necessary to retain the micro colour filters 82 to allow the LCD to operate in a reflective mode when the ambient light level is sufficiently high, and therefore reduce the power consumption of the device.

A difficulty with the earlier embodiments (Figures 2, 4, 6 and 8), can be understood by considering Figure 11. Reflected light must make two passes through the colour filters 82, whereas (white) light transmitted from the backlight 96 makes only a single pass through each colour filter 82. In order to achieve a satisfactory brightness level in reflection it is necessary to use wide band colour filters 82, which let through a wide range of light frequencies. However, this results in a lower colour saturation. That is, reflected light from the LCD appears whiter in colour to the observer 20. The problem is worse for transmission, because transmitted light makes only a single pass through the colour filters 82, and the colour saturation is therefore lower.

The light throughput and high resolution capability in the transmissive mode can be improved in the following way. Instead of coating each micro colour filter 82 continuously and evenly over the pixel area, each micro colour filter 82 can be provided with a transparent region, and the remainder of the area of the micro colour filter 82 can be made more absorbing (ie. more narrow band). For example, for the green micro colour filters 82, the remainder of the micro colour filter 82 can be made more green, so that in the reflective mode no change is perceived by the observer 20 because the transparent region is compensated for by the "more green" region. The same can be done for the red and blue micro colour filters 82. An advantage is achieved in the transmission mode because the transparent regions transmit light of any colour, and thus every micro colour filter 82 is better adapted to transmit light from any of the coloured LEDs 102, 104 and 106.

If the liquid crystal is provided with partially reflecting electrodes having transmissive areas, the transmissive areas can be optically aligned with said transparent regions. A black and white (greyscales) embodiment is also possible, which does not use differently coloured filters and backlights.

Figure 13 shows the electrooptic response of the embodiment of Figure 12. The transmission results are shown by curve 120, and the reflection results by curve 122. The results below about 1.6V are not useful, as the liquid crystal cannot be used for fast

switching in this region. The display 100 should therefore be used in the range 1.6V to 5V.

Figure 14 shows the wavelength dependence of the electooptic response of the embodiment of Figure 12. The transmission and reflection results when the display 100 is switched to the "on" state are shown by curves 124 and 126 respectively. The transmission and reflection results when the display 100 is switched to the "off" state are shown by curves 128 and 130 respectively. It will be seen from these results that the wavelength dependence is reasonably flat over the wavelengths of interest (ie from blue to red).

It should be appreciated that whilst the second aspect of the invention, relating to a time sequential transflective display using differently coloured flashing backlights can be used in conjunction with the first aspect of the invention, it is not so limited. In particular, the second aspect of the invention can be used with any transflective display.

CLAIMS

1. (Amended) A transflective liquid crystal display comprising

a liquid crystal [cell] (38) disposed between a front substrate (40) and a rear substrate (36),

a front polariser (46) located in front of the front substrate and rear polariser (32) located behind the rear substrate,

a front retarder (42,44) located between the front substrate and the front polariser, and

a rear retarder (62,64) located between the rear substrate and the rear polariser, and addressing means for addressing each pixel and switching each pixel between different states resulting in different levels of transmission of light through the display, characterised in that,

a light source (30) is located behind the rear polariser, and

the liquid crystal display is provided with a rear electrode which is partially reflective and partially transmissive and the liquid crystal is divided into a plurality of pixels.

2. (Maintained) A transflective display as claimed in claim 1 wherein the front retarder is an achromatic combination retarder.

3. (Maintained) A transflective display as claimed in claim 1 or 2, wherein the front retarder comprises a front halfwave plate and a ftont quarterwave plate.

4. (Amended) A transflective display as claimed in claim 3, wherein the front quarterwave plate has a slow axis substantially parallel or normal to a bisetrix of surface alignment directions of the liquid crystal, such that a retardation [that] of the front quarterwave plate, in conjunction with the retardation of the liquid crystal [layer], produces in one state circular polarised light after a single pass.

5. (Amended) A transflective display as claimed in claim 3 or 4, wherein the front quarterwave plate has a slow axis substantially parallel or normal to a bisetrix of surface alignment directions of the liquid crystal, such that a retardation [that] of the front quarterwave plate, in conjunction with the retardation of the liquid crystal [layer], produces in a second state linear polarised light after a single pass.

6. (Amended) A transflective display as claimed in claim 3, 4 or 5, wherein the front quarterwave plate has a retardation of [between 0 nm and] 50nm and 250 nm.

7. (Maintained) A transflective display as claimed in any preceding claim, wherein thc rear retarder comprises a rear quarterwave plate.

8. (Amended) A transflective display as claimed in claim 7, wherein the rear quarterwave plate has a slow axis substantially parallel or normal to a bisetrix of surface alignment directions of the liquid crystal, such that a retardation [that] of the rear quarterwave plate,

in conjunction with the retardation of the liquid crystal [layer] and the front quarterwave plate, produces in one state circular polarised light after a single pass.

9. (Amended) A transflective display as claimed in claim 7 or 8, when also dependent, directly or indirectly, on claim 3, wherein the rear quarterwave plate has a slow axis substantially parallel or normal to a bisetrix of surface alignment directions of the liquid crystal, such that a retardation [that] of the rear quarterwave plate, in conjunction with the retardation of the liquid crystal [layer] and the front quarterwave plate, produces in a second state linear polarised light after a single pass.

10. (Maintained) A transflective display as claimed in claim 7, 8 or 9, wherein the rear quarterwave plate has a retardation of between 100nm and 180nm.

11. (Maintained) A transflective display as claimed in any preceding claim, wherein the rear substrate is provided with a partially reflective and partially transmissive mirror.

12. (Cancel)

13. (Maintained) A transflective display as claimed in any preceding claim, wherein the rear retarder further comprises a rear halfwave plate.

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14. (Maintained) A transflective display as claimed in claim 13, when also dependent directly or indirectly on claim 6, wherein the rear halfwave plate is located between the rear quarterwave plate and the rear polariser.

15. (Amended) A transflective display comprising a liquid crystal divided into a plurality of pixels, addressing means for addressing each pixel and swithing each pixel between different states resulting in different levels of transmission of light through the display, a flashing backlight located behind the liquid crystal, and a partially reflective mirror located between the liquid crystal and the backlight for both reflecting ambient light back through the liquid crystal and allowing transmission of light from the backlight through the liquid erystal, characterised in that each pixel is provided with a light filter (82), and _ the backlight comprises a plurality of sequentially flashing light sources (102, 104, 106).

16. (Maintained) A transflective display as claimed in claim 15, wherein each light filter is a colour light filter, and wherein said sequentially flashing light sources are of different colours.

17. (Maintained) A transflective display as claimed in claim 16, wherein said liquid crystal is part of an active matrix display.

18. (Maintained) A transflective display as claimed in claim 15, 16 or 17, wherein the liquid crystal forms a Pi or OCB cell.

19. (Amended) A transflective display as claimed in any one of claims 15 to 18, wherein each <u>said sequentially flashing</u> light source is a light emitting diode (LED).

20. (Maintained) A transflective display as claimed in any one of claims 16 to 19, wherein each colour filter provides a varying level of absorption across its area.

21. (Maintained) A transflective display as claimed in claim 20, wherein each colour filter has a transparent region.

22. (Maintained) A transflective display as claimed in claim 21, wherein said liquid crystal is provided with a plurality of partially reflective electrodes each having a light transmissive area, and wherein each said transmissive area is optically aligned with a transparent region of one of said colour filters.

23. (Maintained) A transflective display as claimed in any one of claims 15 to 22, which also has any or all of the features of the transflective display of claims 1 to 14.

24. (Cancel)

25. (Added) A transflective display as claimed in any one of claims 11 and 15 to 24, wherein said partially

reflective and partially transmissive mirror comprises a plurality of gaps or holes.

26. (Added) A transflective display as claimed in any one of claims 11 and 15 to 25, wherein said partially reflective and partially transmissive mirror is a mirror transparent to a predetermined value between 10 and 90%.

27. (Added) A transflective display as claimed in any one of claims 16 to 26, wherein for transmission, transflective and reflection modes of the transflective display a voltage level for each said different colour is individually adjusted.

28. (Added) A transflective display as claimed in any one of claims 1 to 27 wherein said front and rear polarisers are parallel polarisers.

29. (Added) A transflective display as claimed in any one of claims 1 to 27, wherein said front and rear polarisers are crossed polarisers.

30. (Added) A transflective display as claimed in anyone of claims 1 to 29, in which the effective retardation of the nematic CL is continuously switchable, and, the two front retarders function together as an achromatic combination rotarder.

31. (Added) A transflective display as claimed in anyone of claims 1 to 29, in which the effective retardation of the nematic CL is continuously switchable, and, the two

rear retarders function together as an achromatic combination rotarder.

32. (Added) A transflective display as claimed in any one of claims 1 to 29, in which the front quarter wave plate has its slow axis substantially normal or parallel to the bisectrix of the surface director orientations of the nematic LC, and the two front retarders form an achromatic combination retarder, and the combination retarder is modified to compensate for the residual retardation of the LC at finite voltages.

33. (Added) A transflective display as claimed in any one of claims 1 to 29, in which the rear quarter wave plate has its slow axis substantially normal or parallel to the bisectrix of the surface director orientations of the nematic LC, and the two rear retarders form an achromatic combination retarder, and the combination retarder is modified to compensate for the residual retardation of the LC at finite voltages.

34. (Added) A transflective display as claimed in any one of claims 1 to 29, which the nematic LC has antiparallel surface director orientation with surface pretilt, and the front substrate functions as a colour filter plate.

35. (Added) A transflective display as claimed in any one of claims 1 to 29, which the red, green and blue voltage levels are individually adjusted for transmission, transflective or reflection modes, and the transmission/reflection against voltage curve is

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wavelength dependent and is different between the reflective and the transmissive mode.

36. (Added) A transflective display as claimed in any of claims 15 to 29, in which the nematic LC has substantially parallel surface director orientations .

36. (Added) A transflective display as claimed in claim 35, in which the nematic LC is formed from a Pi cell.

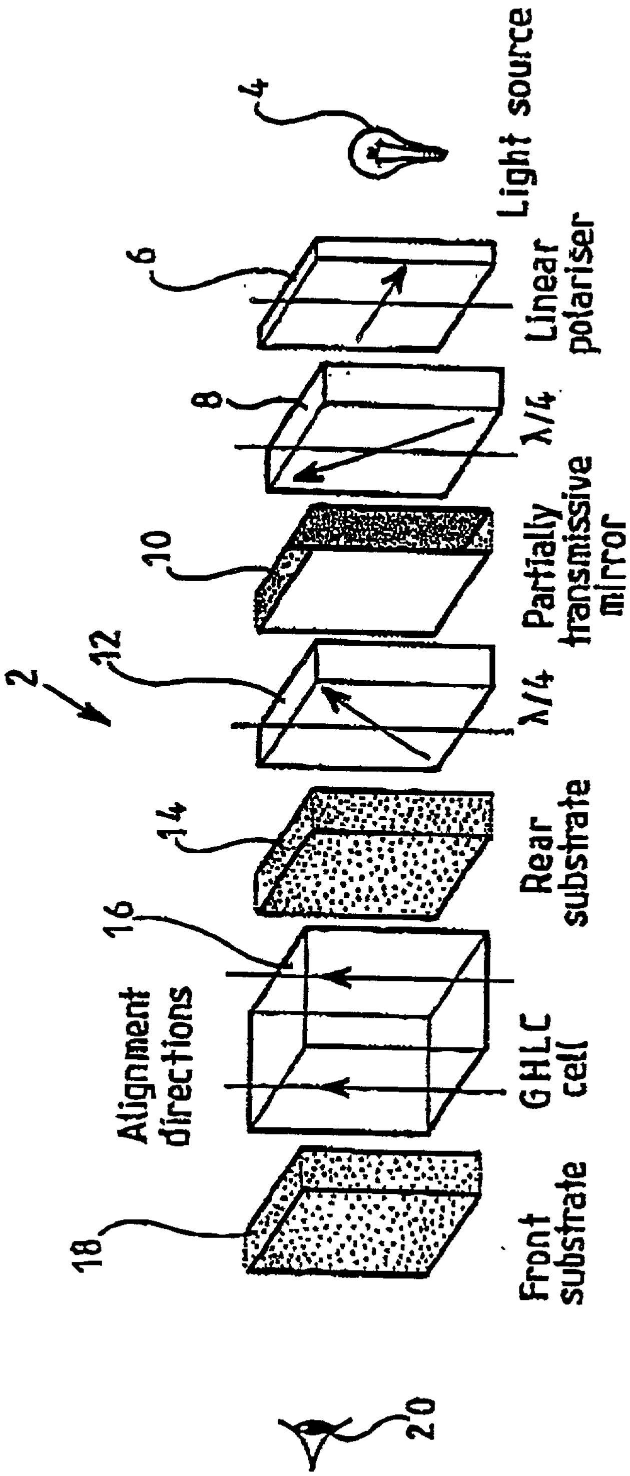

4
Light source
6
Linear polariser
8
λ/4
10
Partially transmissive mirror
2
12
λ/4
14
Rear substrate
16
Alignment directions
GHLC cell
18
Front substrate
20

FIG 1

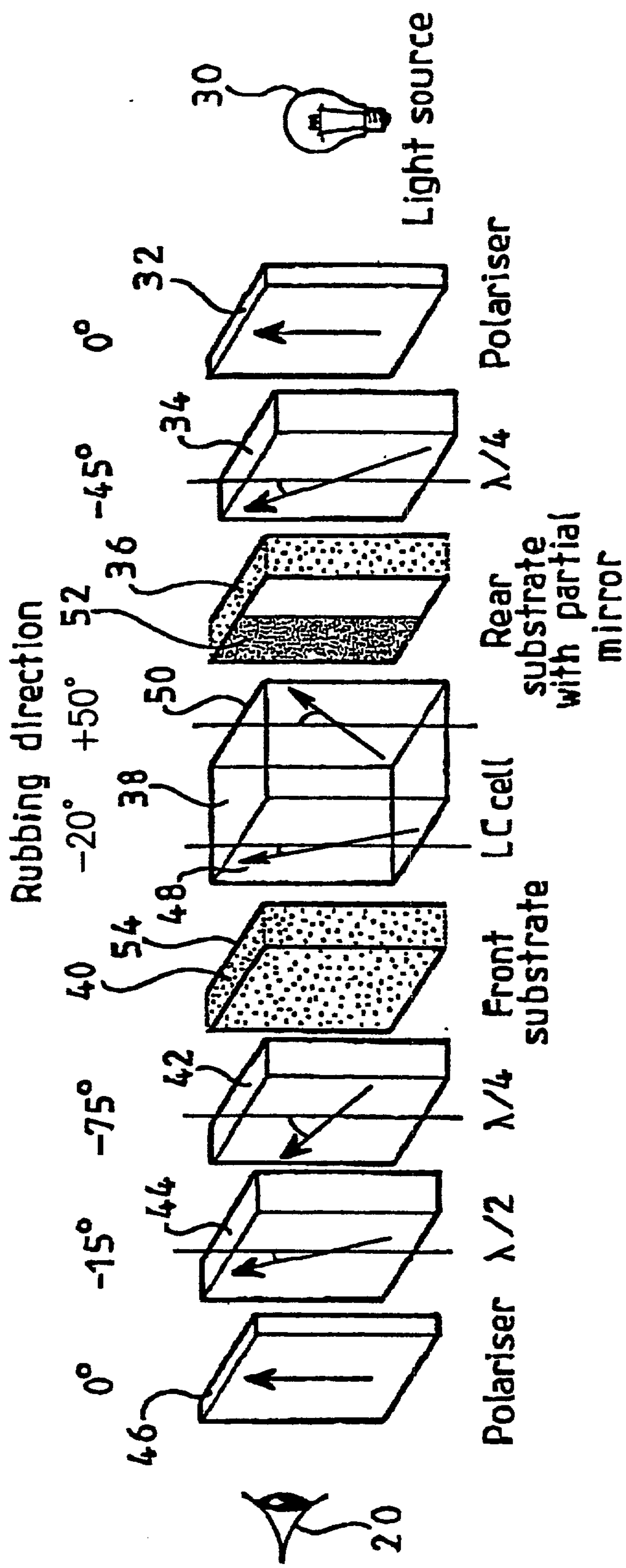

28
Rubbing direction
0°
-15°
-75°
-20°
+50°
-45°
0°
46
44
42
40
54
48
38
50
52
36
34
32
30
20
Polariser
λ/2
λ/4
Front substrate
LC cell
Rear substrate with partial mirror
λ/4
Polariser
Light source

FIG 2

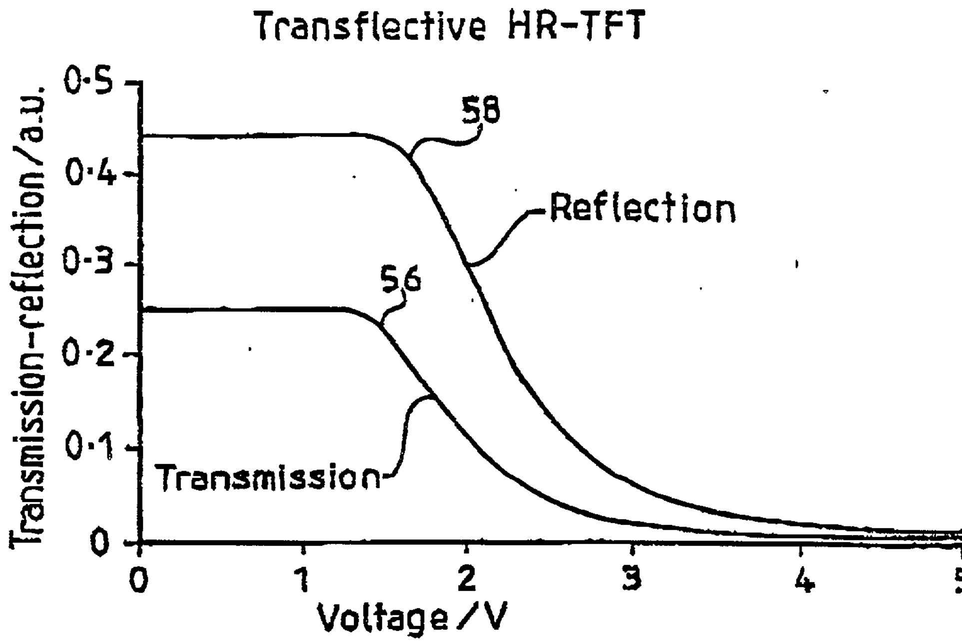

Transflective HR-TFT
Transmission-reflection/a.u.
0·5
0·4
0·3
0·2
0·1
0
58
Reflection
56
Transmission
0
1
2
3
4
5
Voltage/V

FIG 3

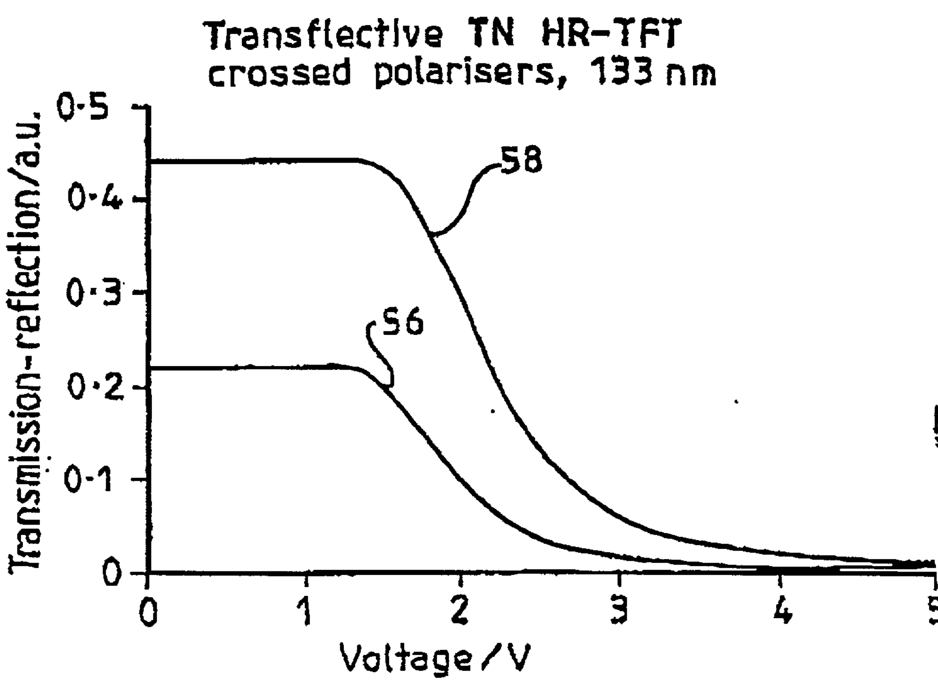

Transflective TN HR-TFT
crossed polarisers, 133 nm
Transmission-reflection/a.u.
0·5
0·4
0·3
0·2
0·1
0
58
56
0
1
2
3
4
5
Voltage/V

FIG 3a

09/787594 JP 009905210

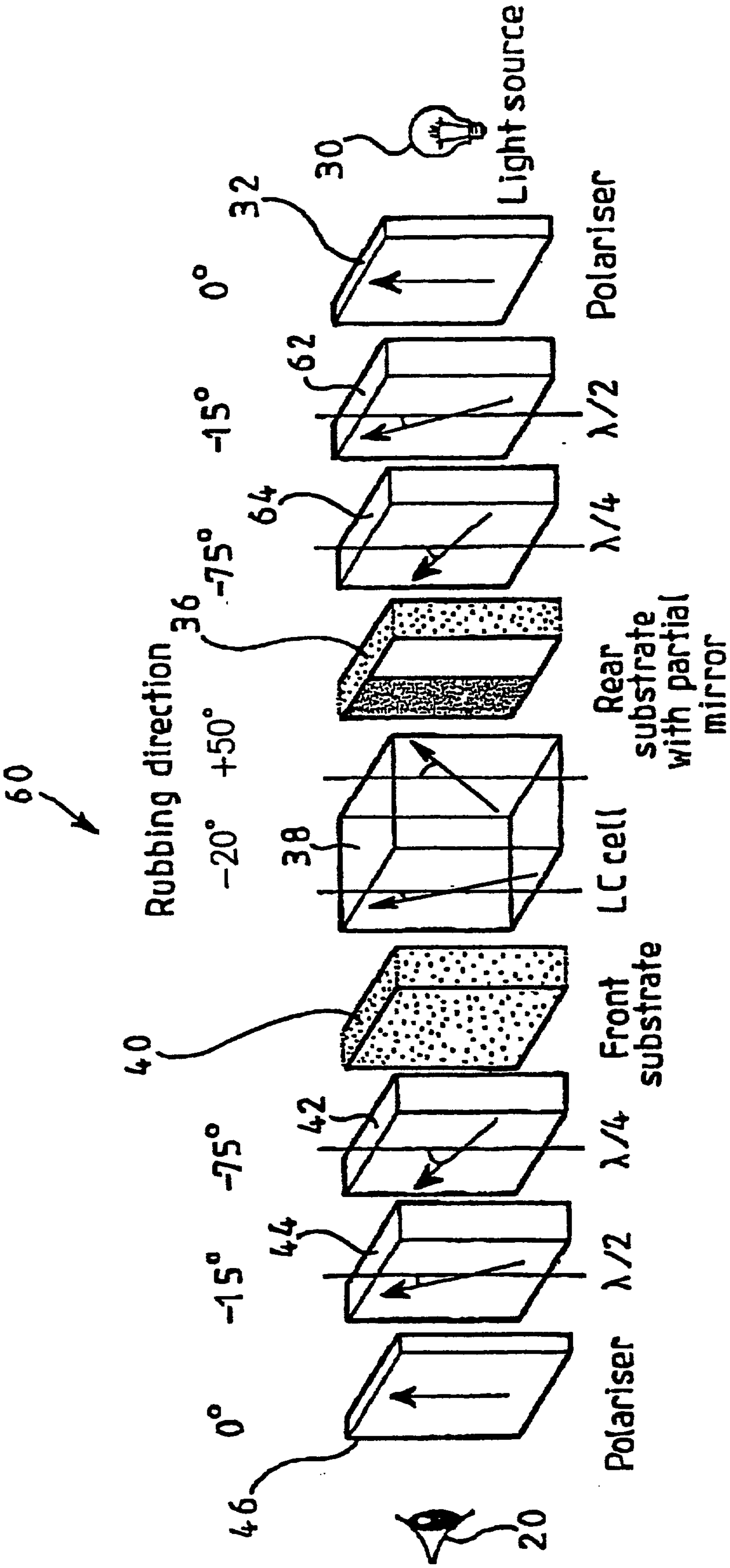


FIG 4

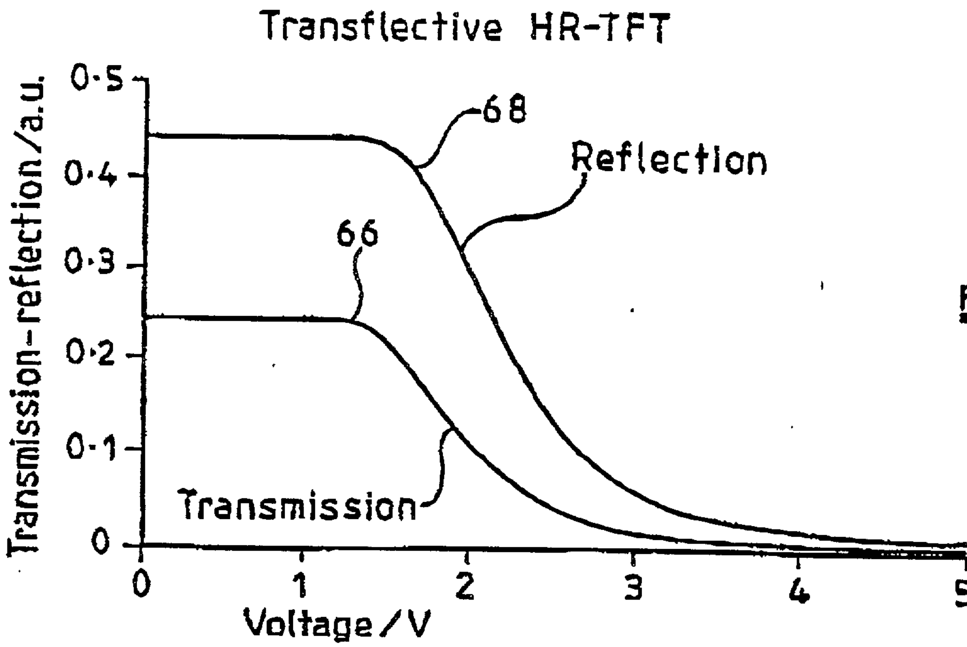

Transflective HR-TFT
Transmission-reflection/a.u.
0·5
0·4
0·3
0·2
0·1
0
68
Reflection
66
Transmission
0
1
2
3
4
5
Voltage/V

FIG 5

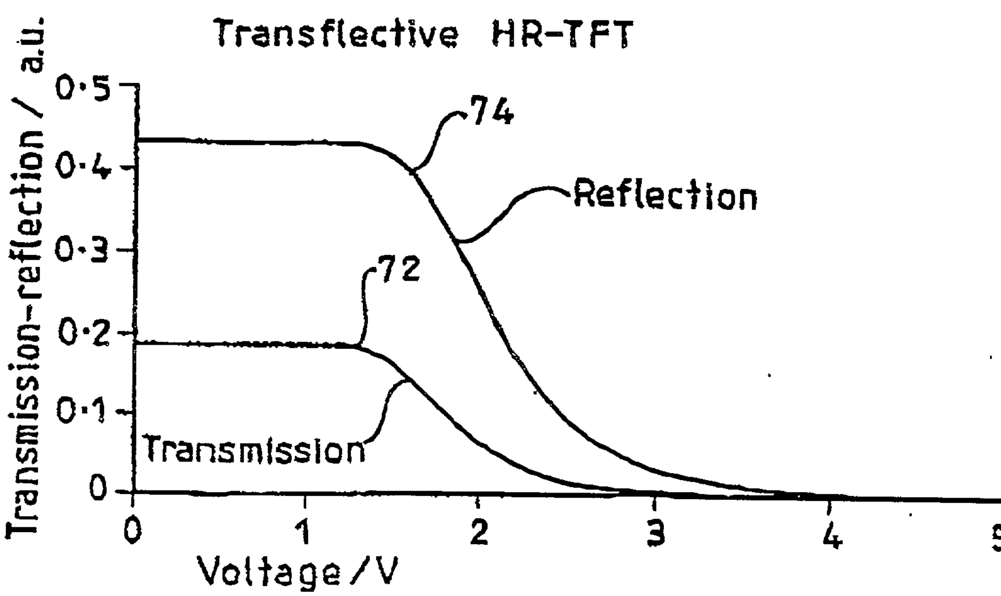

Transflective HR-TFT
Transmission-reflection / a.u.
0·5
0·4
0·3
0·2
0·1
0
74
Reflection
72
Transmission
0
1
2
3
4
5
Voltage/V

FIG7

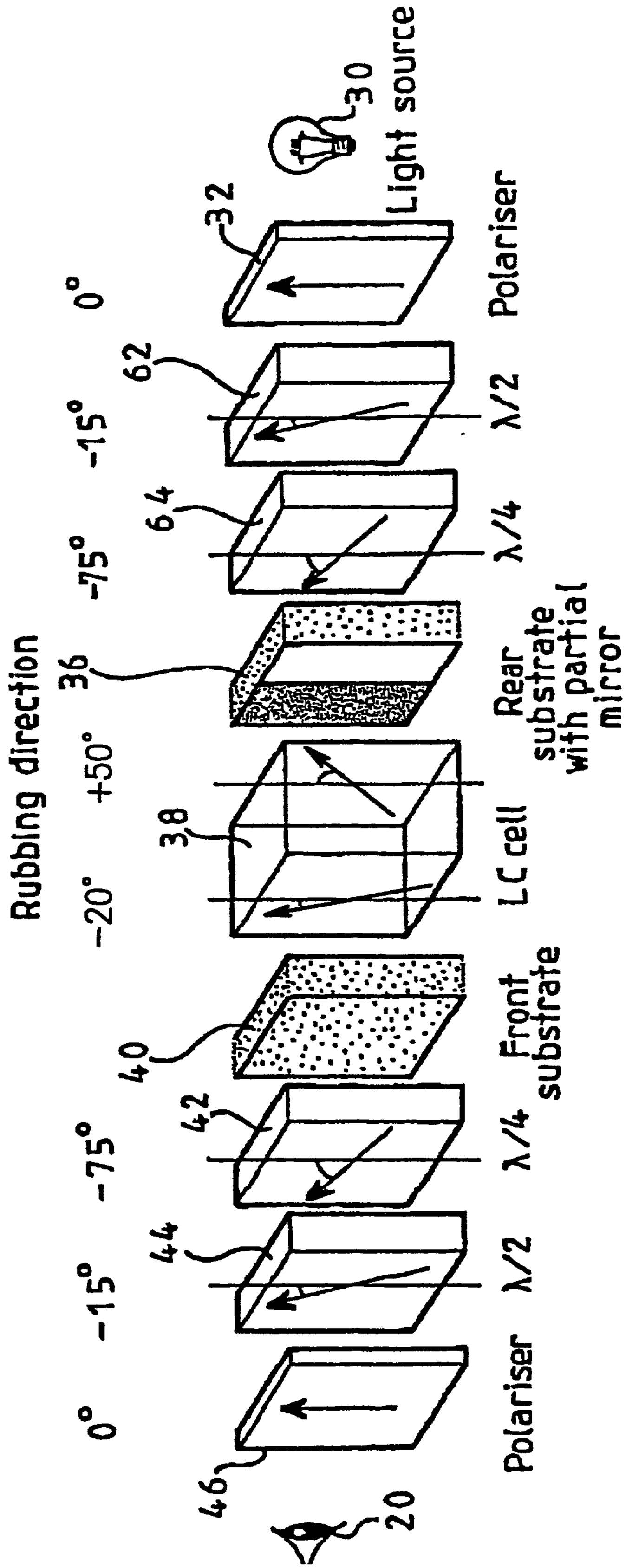

70
Rubbing direction
0°
-15°
-75°
+50°
-20°
-75°
-15°
0°
32
62
64
36
38
40
42
44
46
30
20
Light source
Polariser
λ/2
λ/4
Rear substrate with partial mirror
LC cell
Front substrate
λ/4
λ/2
Polariser

FIG 6

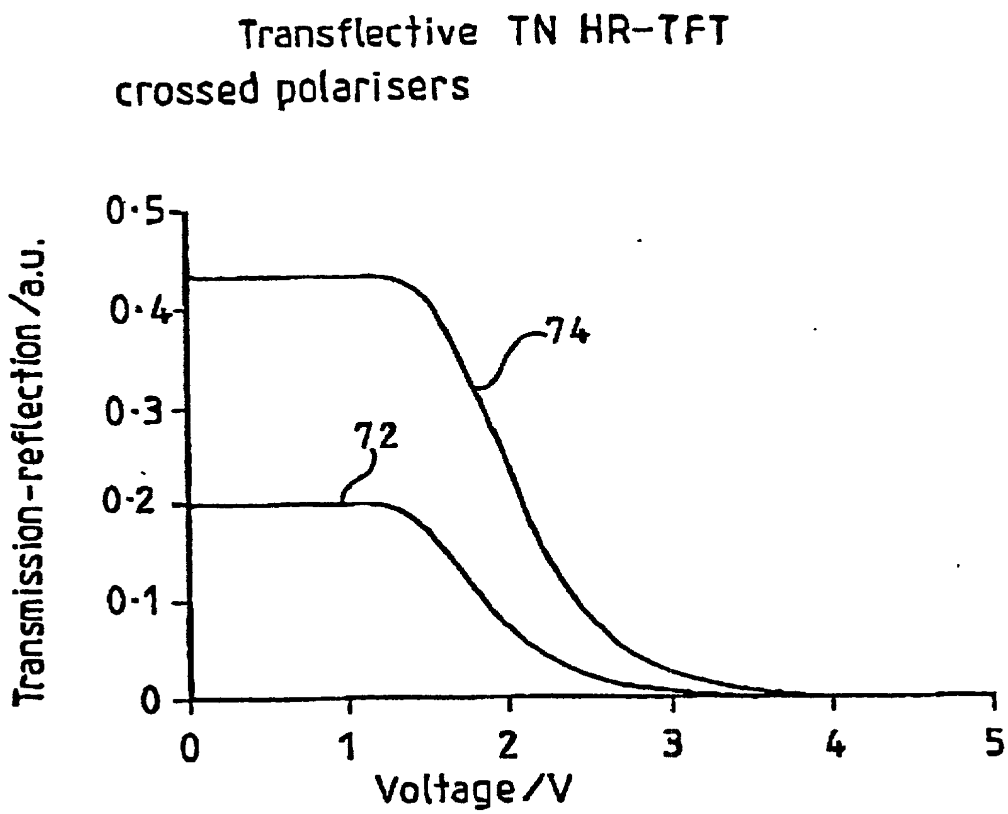

Transflective TN HR-TFT
crossed polarisers
Transmission-reflection /a.u.
0·5
0·4
0·3
0·2
0·1
0
74
72
0
1
2
3
4
5
Voltage/V

FIG 7a

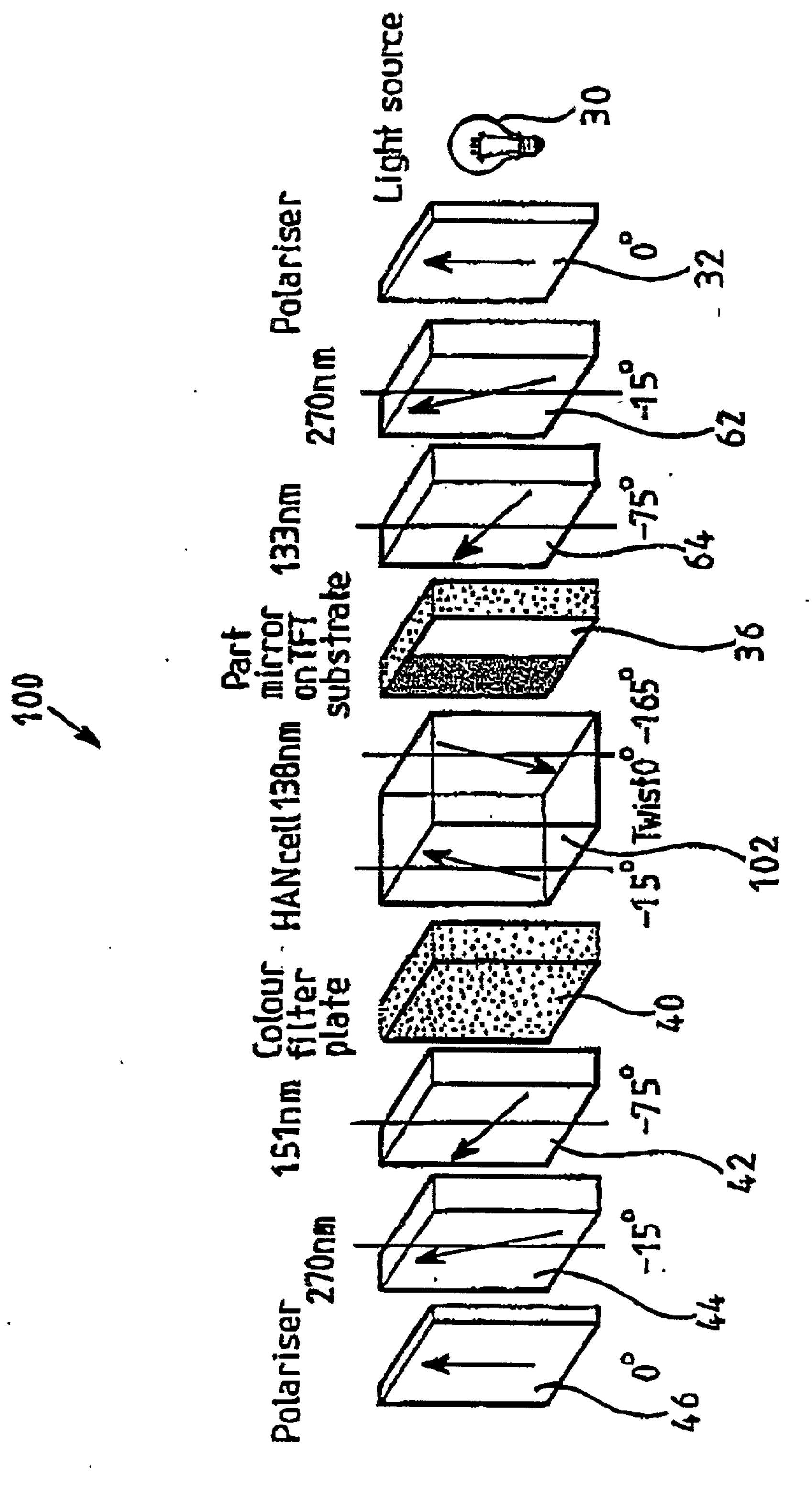

100
Light source
30
Polariser
0°
32
270nm
-15°
62
133nm
-75°
64
Part mirror on TFT substrate
36
HAN cell 138nm
Twist 0° -165°
-15°
102
Colour filter plate
40
151nm
-75°
42
270nm
-15°
44
Polariser
0°
46

FIG 8

Transflective HAN HR-TFT
parallel polarisers

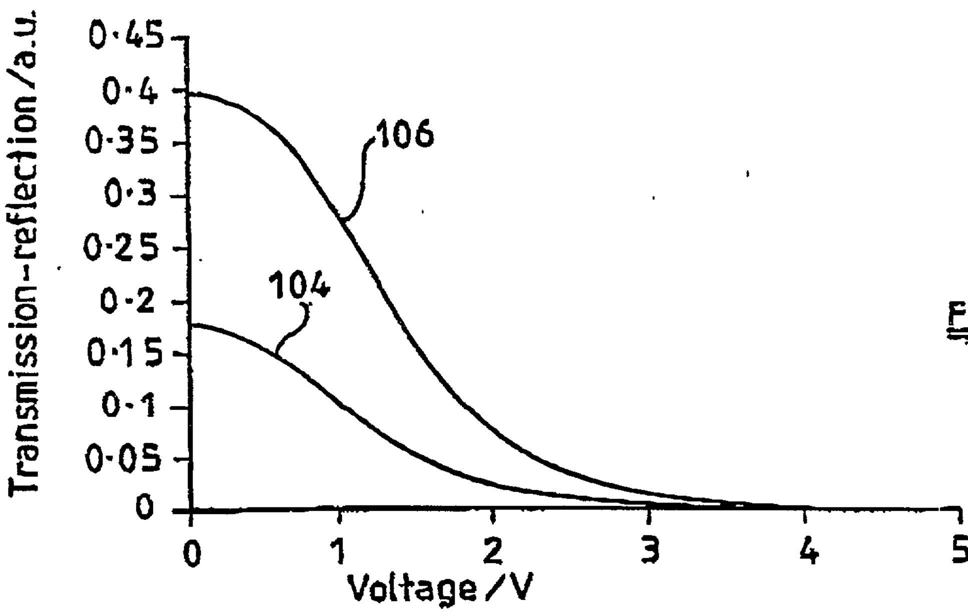


FIG 9

Transflective HAN HR-TFT
crossed polarisers

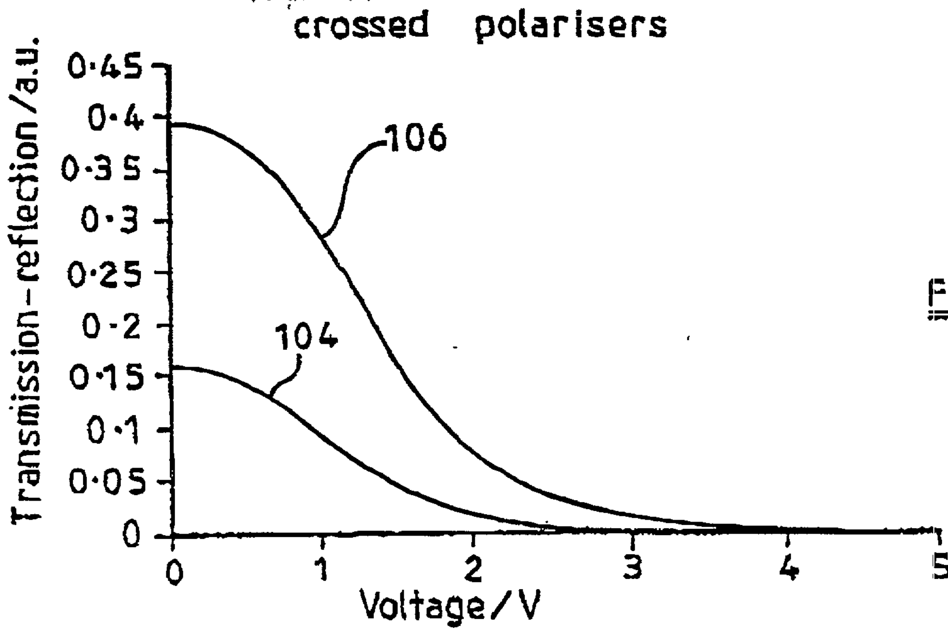


FIG 9a

FIG 10

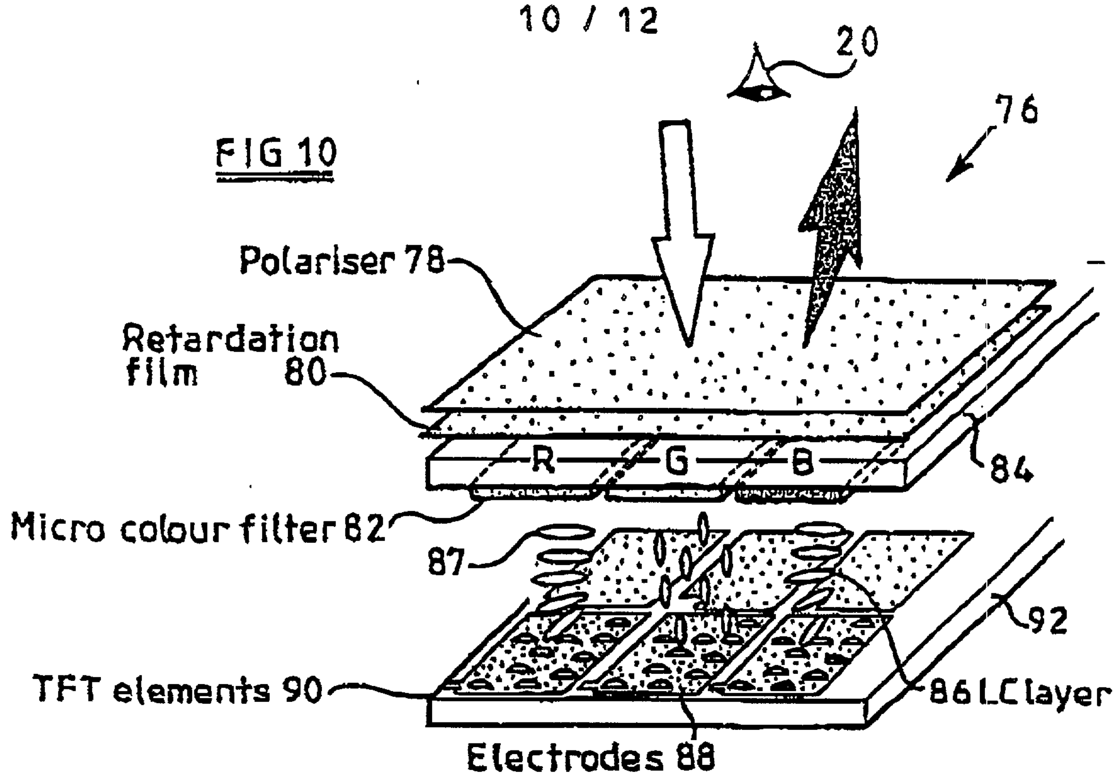
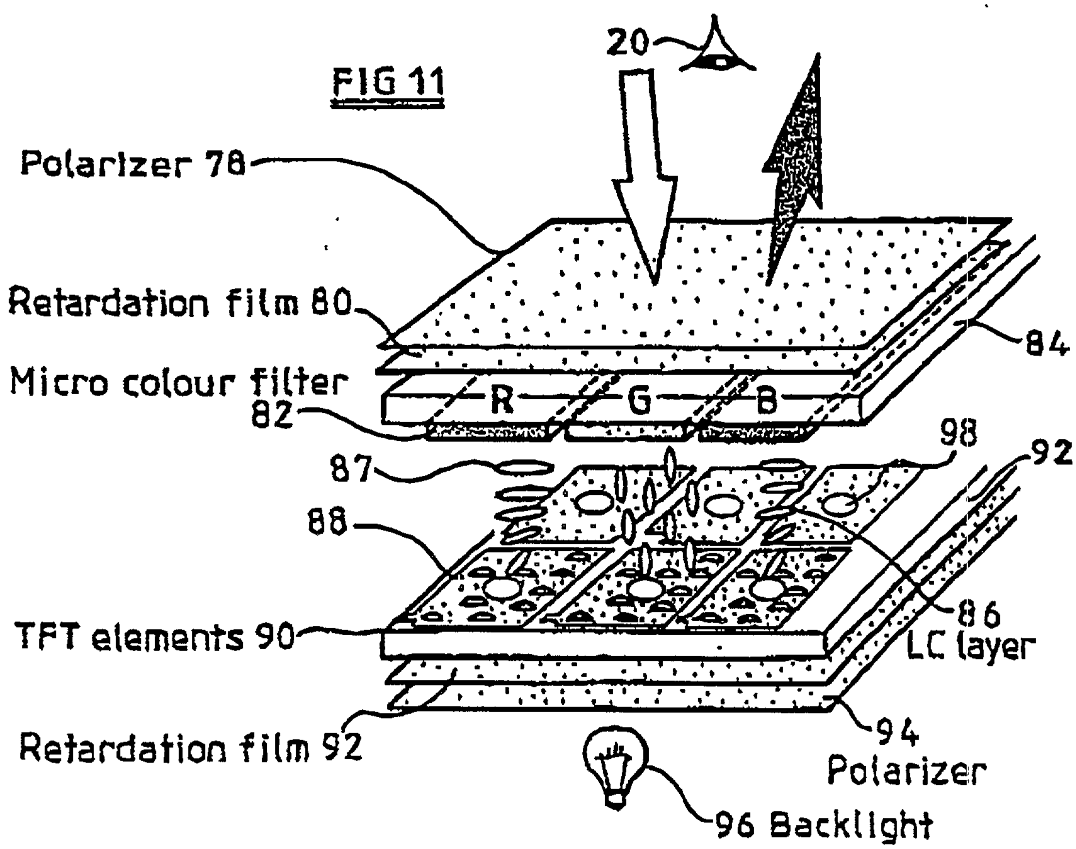

20
76
Polariser 78
Retardation film 80
R
G
B
84
Micro colour filter 82
87
92
TFT elements 90
86 LC layer
Electrodes 88

FIG 11


20
Polarizer 78
Retardation film 80
84
Micro colour filter 82
R
G
B
98
92
87
88
TFT elements 90
86
LC layer
Retardation film 92
94
Polarizer
96 Backlight

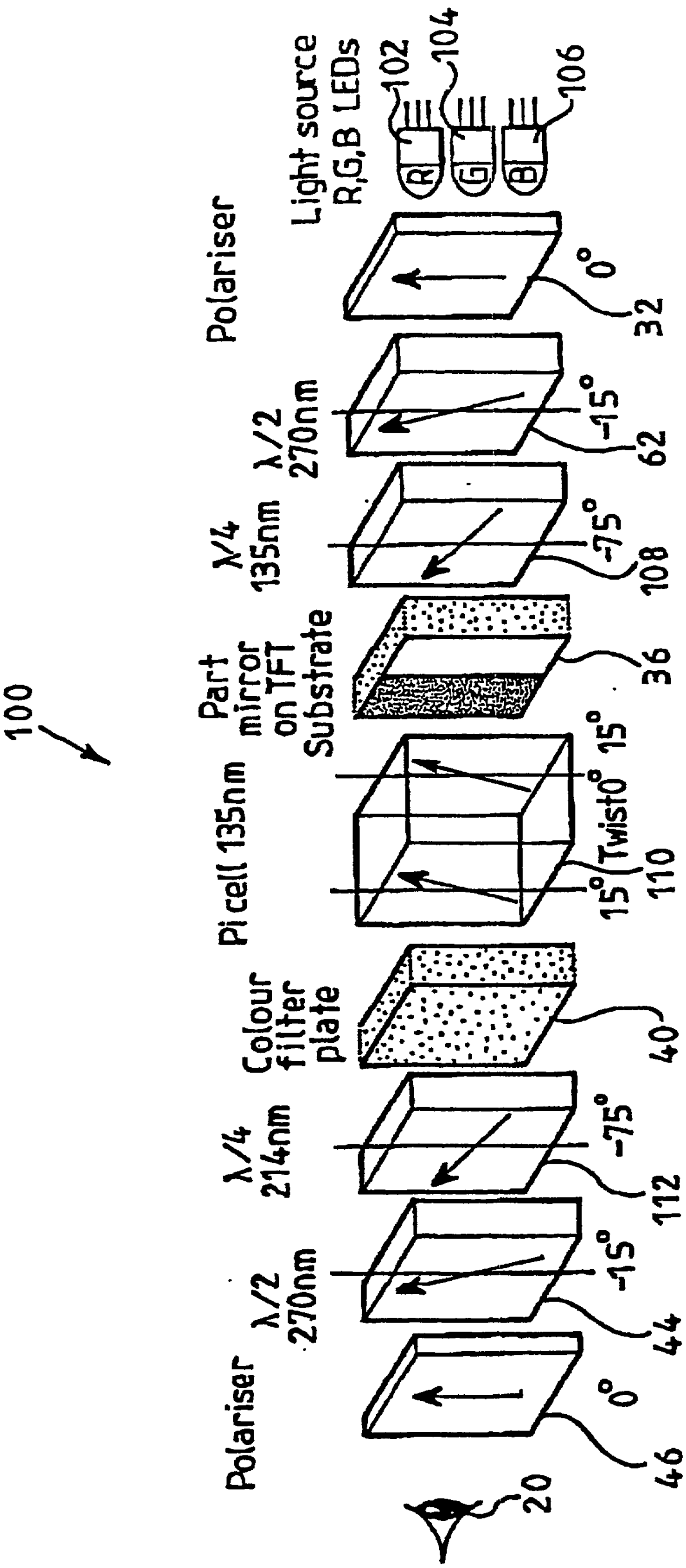

100
Polariser
Light source R,G,B LEDs
102
104
106
R
G
B
0°
32
λ/2 270nm
-15°
62
λ/4 135nm
-75°
108
Part mirror on TFT Substrate
36
Pi cell 135nm
15°
Twist0°
15°
110
Colour filter plate
40
λ/4 214nm
-75°
112
λ/2 270nm
-15°
44
Polariser
0°
46
20

FIG 12

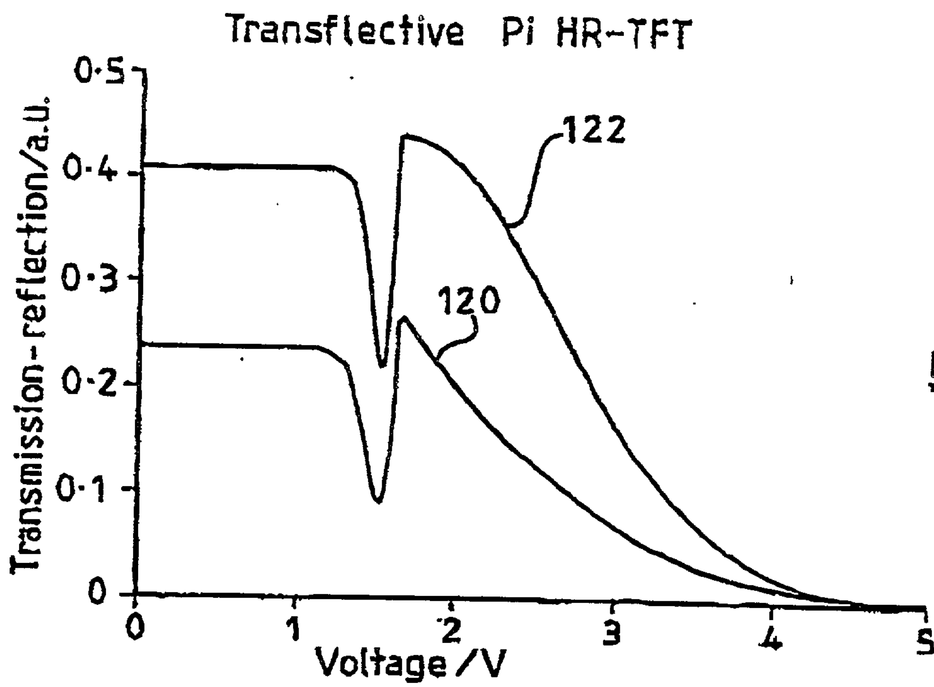

Transflective Pi HR-TFT
Transmission-reflection/a.u.
0·5
0·4
0·3
0·2
0·1
0
122
120
0
1
2
3
4
5
Voltage/V

FIG 13

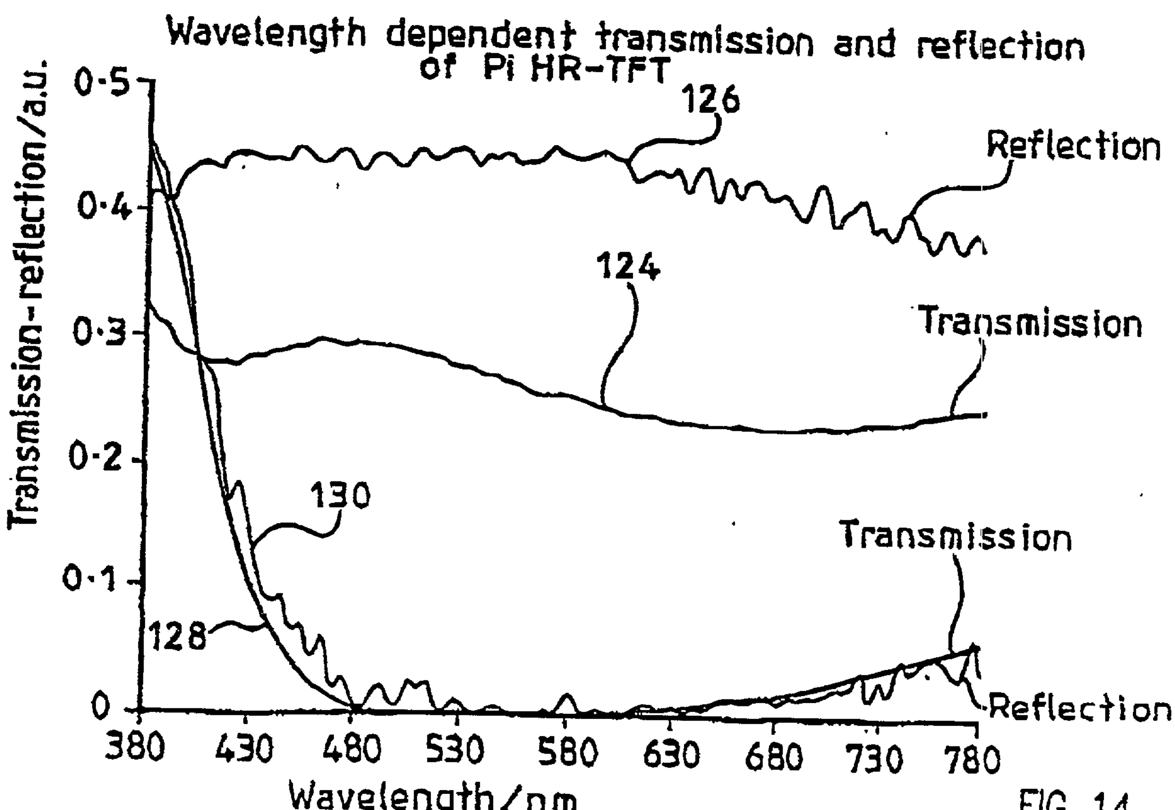

Wavelength dependent transmission and reflection of Pi HR-TFT
Transmission-reflection/a.u.
0·5
0·4
0·3
0·2
0·1
0
126
Reflection
124
Transmission
130
128
Transmission
Reflection
380
430
480
530
580
630
680
730
780
Wavelength/nm

FIG 14

PATENT (US)

Attorney Docket No. YAMAP0757US

COMBINED DECLARATION AND POWER OF ATTORNEY
(ORIGINAL, DESIGN, NATIONAL STAGE OF PCT)

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name, I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Title: TRANSFLECTIVE LIQUID CRYSTAL DISPLAYS

the specification of which

(a) __ is attached hereto.
(b) x was filed on March 20, 2001 as __ Serial No. 0 /________ or X Express Mail No. EF297167718US, as Serial No. not yet known, and was amended on ________ (if applicable).
(c) x was described and claimed in PCT International Application No. PCT/JP99/05210 filed on September 22, 1999 and amended under PCT Article 34 on ________ (if any).

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with Title 37, Code of Federal Regulations §1.56(a).

PRIORITY CLAIM

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed.

(d) __ no such application have been filed.
(e) x such applications have been filed as follows.

EARLIEST FOREIGN APPLICATION(S), IF ANY FILED WITHIN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION

COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119
Great Britain	9820516.4	22/09/98	x Yes __ No

ALL FOREIGN APPLICATION(S), IF ANY FILED MORE THAN 12 MONTHS (6 MONTHS FOR DESIGN) PRIOR TO THIS U.S. APPLICATION

POWER OF ATTORNEY

As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (List name and registration number)

Armand P. Boisselle, Reg. No. 22,381; Neil A. DuChez, Reg. No. 26,725; Mark D. Saralino, Reg. No. 34,243

The undersigned to this declaration and power of attorney hereby authorizes the U.S. attorney(s) named herein to accept and follow instruction from

Name(s) of authorized representation(s) Shusaku Yamamoto Patent Law Office
Address Fifteenth Floor, Crystal Tower, 1-2-27 Shiromi, Chuo-Ku, Osaka 540, Japan

as to any actions to be taken in the Patent and Trademark Office regarding this application without direct communication between the U.S. attorney(s) and the undersigned. In the event of a change in the person(s) from whom instructions may be taken, the U.S. attorney(s) will be so notified by the undersigned.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with knowledge that willful false statements and the like are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued therein.

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Post Office Address

CHECK FOR ANY OF THE FOLLOWING ADDED PAGE(S) WHICH
FORM A PART OF THIS DECLARATION

___ Signature for fourth and subsequent joint inventors. Number of pages added___.
___ Added page to combined declaration and power of attorney for divisional, continuation, or continuation-in-part (CIP) application.
x This declaration ends with this page.